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(54) Manual input device for controlling a robot arm

(57) A six-axis input device, e.g. joystick (10), is supported by a mechanism (20) which enables the joystick (10) to be aligned with any desired orientation, e.g. parallel to the tool (18). The mechanism (20) can then be locked to provide a rigid support for the joystick (10). The mechanism may include three pivotal joints (26) whose axes are perpendicular, each incorporating a clutch. The clutches may be electromagnetic or mechanical and may be operable jointly or independently. The robot arm (14) comprises a base (15) rotatable about a vertical axis (A), an upper arm (16), a forearm (17) and a tool or grip (18) rotatable about three perpendicular axes relative to the forearm (17).

Fig.1

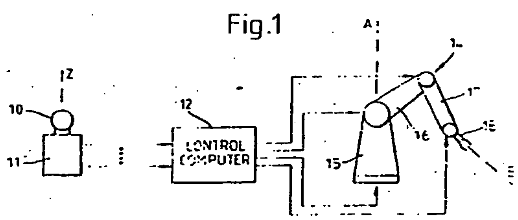

Fig.2

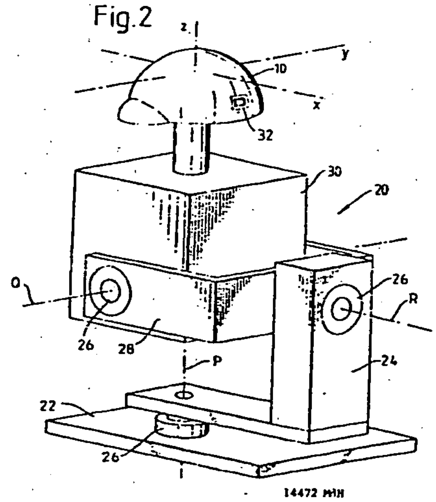

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Fig.1

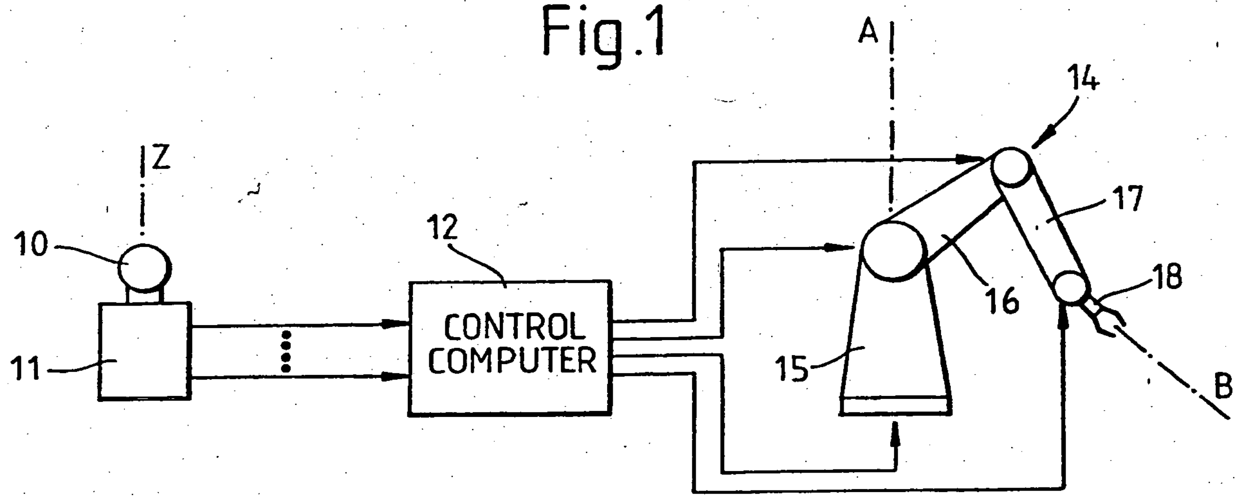
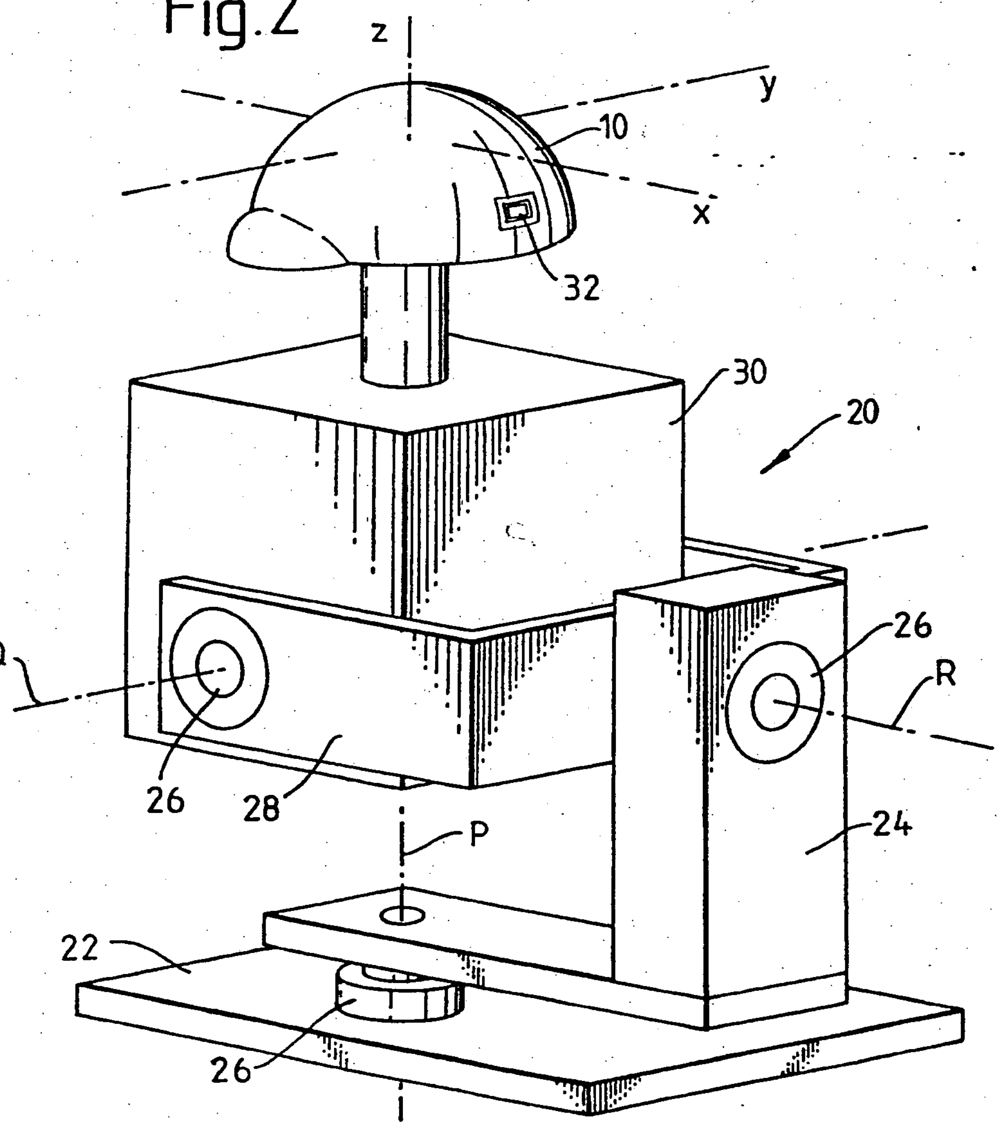

A
14
Z
17
10
12
18
CONTROL
COMPUTER
16
11
15
B

Fig.2


z
y
10
x
32
30
20
26
Q
R
26
28
P
24
22
26

Manual controller

This invention relates to apparatus for manually controlling operation of a robot arm.

It is known that a robot arm may be controlled by an operator using a master arm, every movement imposed on the master arm being performed by the robot arm. The master arm may be linked mechanically (eg by chains or cables) to the robot arm, so the mechanical links transmit the desired movements, and in such a context the robot arm is usually referred to as a manipulator slave arm. Alternatively each joint of the robot arm may be powered by a motor such as an electric motor to which appropriate control signals are supplied. The control signals may be provided by sensors in corresponding joints of a master arm. Alternatively the control signals can be provided by a computer in response to signals from an input device. The input device might be a keyboard; or it might be a compliant or non-compliant six-axis input device such as a joystick.

Such a six-axis input device provides signals representing displacement or force exerted by the operator in the direction of three perpendicular axes, and signals representing angular displacement or torque exerted by the operator around each of those three axes (whether the signals represent displacements, or force and torques, depends on whether the device is compliant or not). These signals are interpreted by the computer, which causes the robot arm joints to move so that a tool held by the robot arm undergoes corresponding displacements and rotations.

According to the present invention there is provided an apparatus for manually controlling a robot arm, the

apparatus comprising a six-axis input device and support means for the input device, wherein the support means comprises orientation means to enable the input device to be given any desired orientation, and means to lock the orientation means when the desired orientation is achieved such that when locked the support means is substantially rigid.

In the preferred embodiment the support means incorporates a gimballed mounting allowing rotation about three perpendicular axes, and clutch mechanisms to lock and unlock each axis. Preferably the clutch mechanisms are locked or unlocked by operation of a single switch, which is desirably located on the input device. This arrangement enables an operator to control a robot arm single-handedly.

The invention will now be further described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 shows diagrammatically a robot arm and a manual control system; and

Figure 2 shows a perspective view of a manual control apparatus of the invention.

Referring to Figure 1, a six-axis joystick 10 on a fixed suppport 11 is connected to a control computer 12, and the computer 12 is connected to a robot arm 14. The robot arm 14 in this case has a base 15 rotatable about a vertical axis A, an upper arm 16 pivotally rotatable relative to the base 15 and a forearm 17 pivotally rotatable relative to the upper arm 16, and carries at its end a tool or grip 18 rotatable about three perpendicular axes relative to the forearm 17. Each of these rotations

is brought about by a corresponding electric motor, controlled by signals provided by the computer 12.

If an operator applies forces to the joystick 10 in the x, y and z directions (these axes being mutually perpendicular and being defined relative to the support 11, and only the z-axis being shown in Figure 1), then the computer 12 causes appropriate motors in the robot arm 14 to be energised to bring about corresponding displacements of the tool or grip 18. If an operator applies torques to the joystick 10, then corresponding motors in the wrist bring about corresponding rotations of the tool or grip 18 relative to the forearm 17. That is just one way in which the six degrees of freedom available in applying forces or torques to the joystick 10 can be used to control the movements of the robot arm 14 and the orientation of the tool or grip 18. In particular there are two different ways in which the computer 12 may be programmed to cause displacements of the tool or grip 18, in response to forces applied to the joystick in x, y and z directions: the displacements may be arranged to occur in mutually perpendicular X, Y and Z directions defined relative to the base 15 (this Z-axis being marked A in Figure 1), or to occur in mutually perpendicular X, Y and Z directions defined relative to the tool or grip 18 (this Z-axis being marked B). These two ways may be referred to as world mode and tool mode respectively. World mode is generally easier for an operator when moving a tool to where a task is to be performed, while tool mode is easier for the operator when the task is being performed.

Referring now to Figure 2 a six-axis joystick 10 is mounted on a support structure 20 which enables the orientation of the joystick 10 to be varied. The support structure 20 consists of a fixed base 22, an L-shaped member 24 connected to the base 22 by a pivot mechanism 26,

a yoke member 28 connected to the L-shaped member 24 by a second pivot mechanism 26, and a joystick base block 30 connected to the yoke member 28 by another pivot mechanism 26. Each pivot mechanism 26 incorporates an electromagnetically released clutch, which can be activated by means of a switch 32 on the joystick 10.

When the clutches in the pivot mechanisms 26 are not energised the support structure 20 is substantially rigid, and as described above in relation to Figure 1 an operator can apply forces and torques to it in x, y and z directions (defined relative to the base block 30) to control the robot arm 14. When the switch 32 is operated, the clutches are energised and so the pivot mechanisms 26 are all free. The axes P, Q, R of the pivot mechanisms 26 are mutually perpendicular and intersect each other. An operator can readily change the orientation of the base block 30 and the joystick 10, for example to make it parallel to that of the tool or grip 18 of the robot arm 14. Then by de-energising the clutches the support structure 20 is again rigid with the joystick 10 in its new orientation. Where the robot arm 14 is being controlled in tool mode, the task of the operator is considerably eased by orientating the joystick 10 parallel to the tool 18 in this fashion, as the relationship between movements of the tool 18 and the force applied to the joystick 10 is much easier to comprehend.

It will be appreciated that the gimbal mechanism of the support structure 20 is merely an example of a lockable mechanism to enable the joystick 10 to be freely aligned to a desired orientation and then to be substantially rigid, and may be modified in many ways while remaining within the scope of the invention. For example the pivot mechanisms 26 might incorporate mechanically-operated clutches rather than electromagnetically-operated ones; and the three clutches might be operable independently.

Claims

1. An apparatus for manually controlling a robot arm, the apparatus comprising a six-axis input device and support means for the input device, wherein the support means comprises orientation means to enable the input device to be given any desired orientation, and means to lock the orientation means when the desired orientation is achieved such that when locked the support means is substantially rigid.

2. An apparatus as claimed in Claim 1 wherein the support means incorporates a gimballed mounting allowing rotation about three perpendicular axes, and clutch mechanisms to lock and unlock each axis.

3. An apparatus as claimed in Claim 2 incorporating a single switch means whereby all the clutch mechanisms may be locked or unlocked.

4. An apparatus as claimed in Claim 3 wherein the switch means is located on the input device.

5. An apparatus for manually controlling a robot arm substantially as hereinbefore desribed with reference to, and as shown in, Figure 2 of the accompanying drawings.

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